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Hiramatu et al.

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(54) **ELECTRONIC BALLAST AND LUMINAIRE WITH THE SAME**

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Aug. 7, 2013 (JP) 2013-164307

(51) **Int. Cl.**

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F21V 29/00	(2015.01)
F21S 8/02	(2006.01)
F21V 23/02	(2006.01)
F21V 23/04	(2006.01)
F21Y 101/02	(2006.01)
F21V 29/70	(2015.01)

(52) **U.S. Cl.**

CPC ***H05B 33/0815*** (2013.01); *F21S 8/026* (2013.01); *F21V 23/02* (2013.01); *F21V 23/04* (2013.01); *F21V 29/70* (2015.01); *F21Y 2101/02* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

An electronic ballast includes an AC-DC converter, a DC-DC converter, a cooling device and a power supply. The cooling device is configured to cool the light source. The power supply includes a first power supply configured to generate a first operating voltage from a first voltage obtained from a chopper circuit included in the AC-DC converter to supply the first operating voltage to at least one of the AC-DC converter and the DC-DC converter. The power supply further includes a second power supply configured to generate a second operating voltage from a second voltage obtained from the chopper circuit to supply the second operating voltage to at least the cooling device of the AC-DC converter, the DC-DC converter and the cooling device.

4 Claims, 6 Drawing Sheets

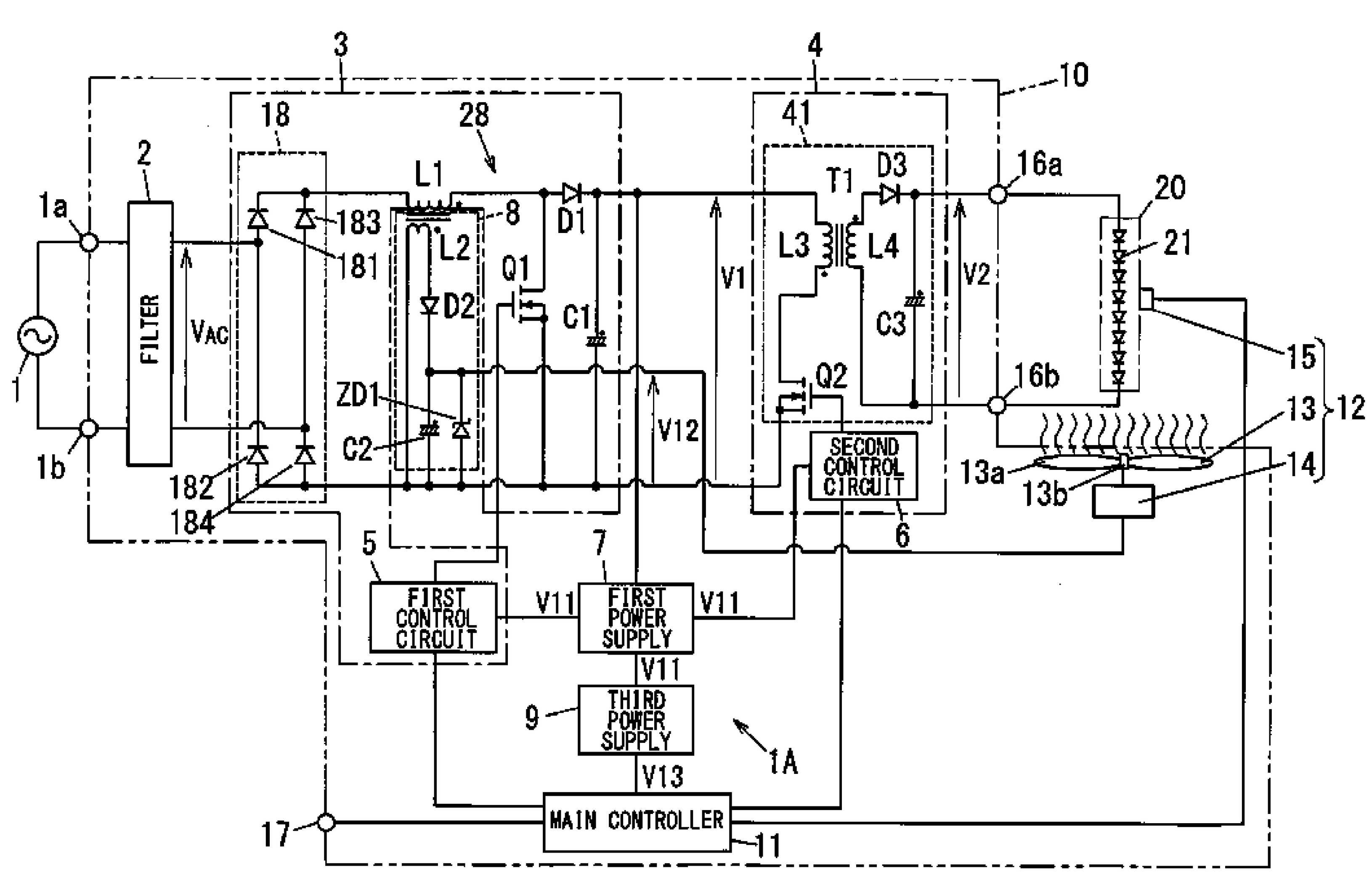

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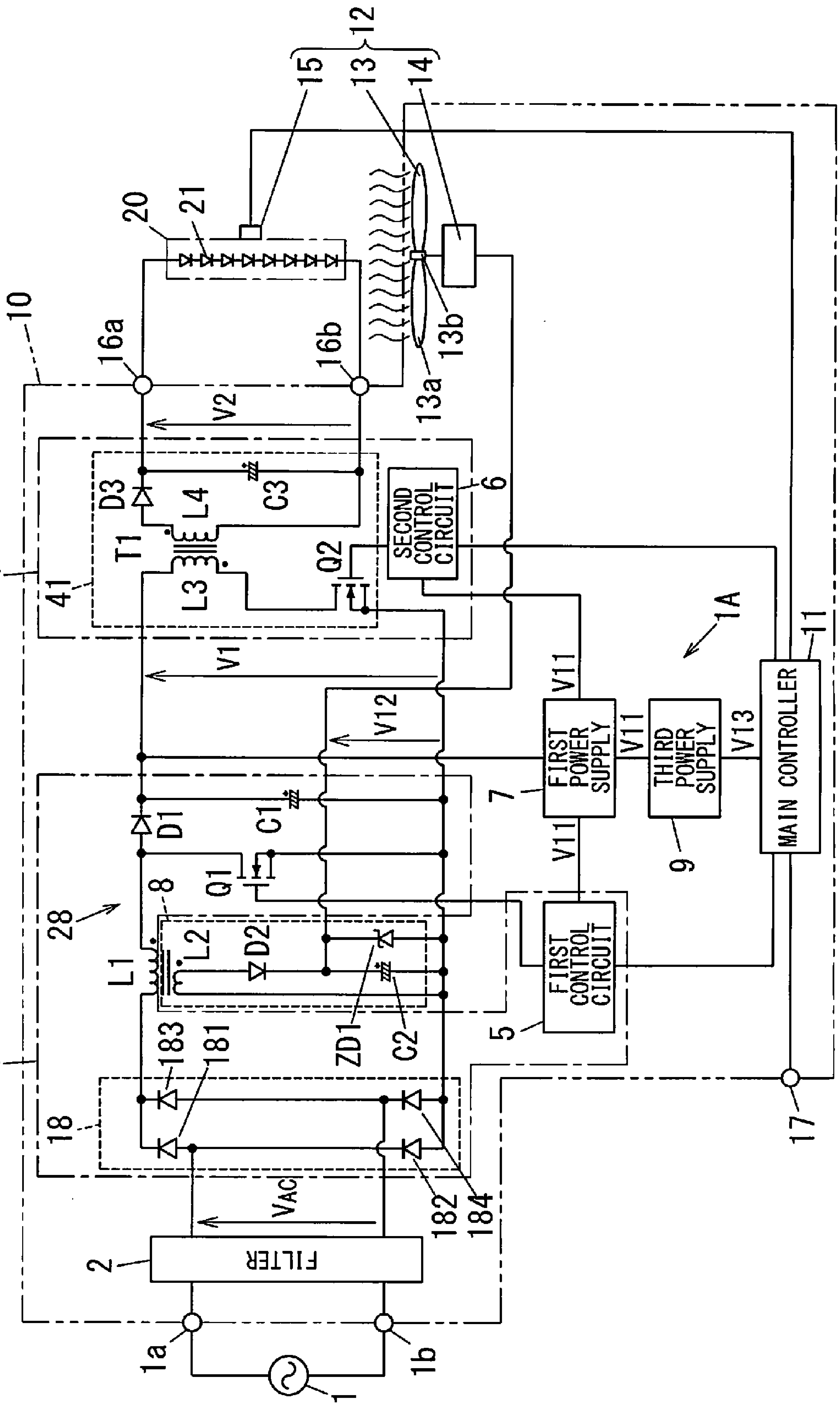
FIG. 1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FIRST POWER SUPPLY
THIRD POWER SUPPLY
SECOND CONTROL CIRCUIT
MAIN CONTROLLER
V11
V12
V13
V1
V2
VAC
L1
L2
L3
L4
T1
D1
D2
D3
C1
C2
C3
Q1
Q2
ZD1
1A

FIG. 2A

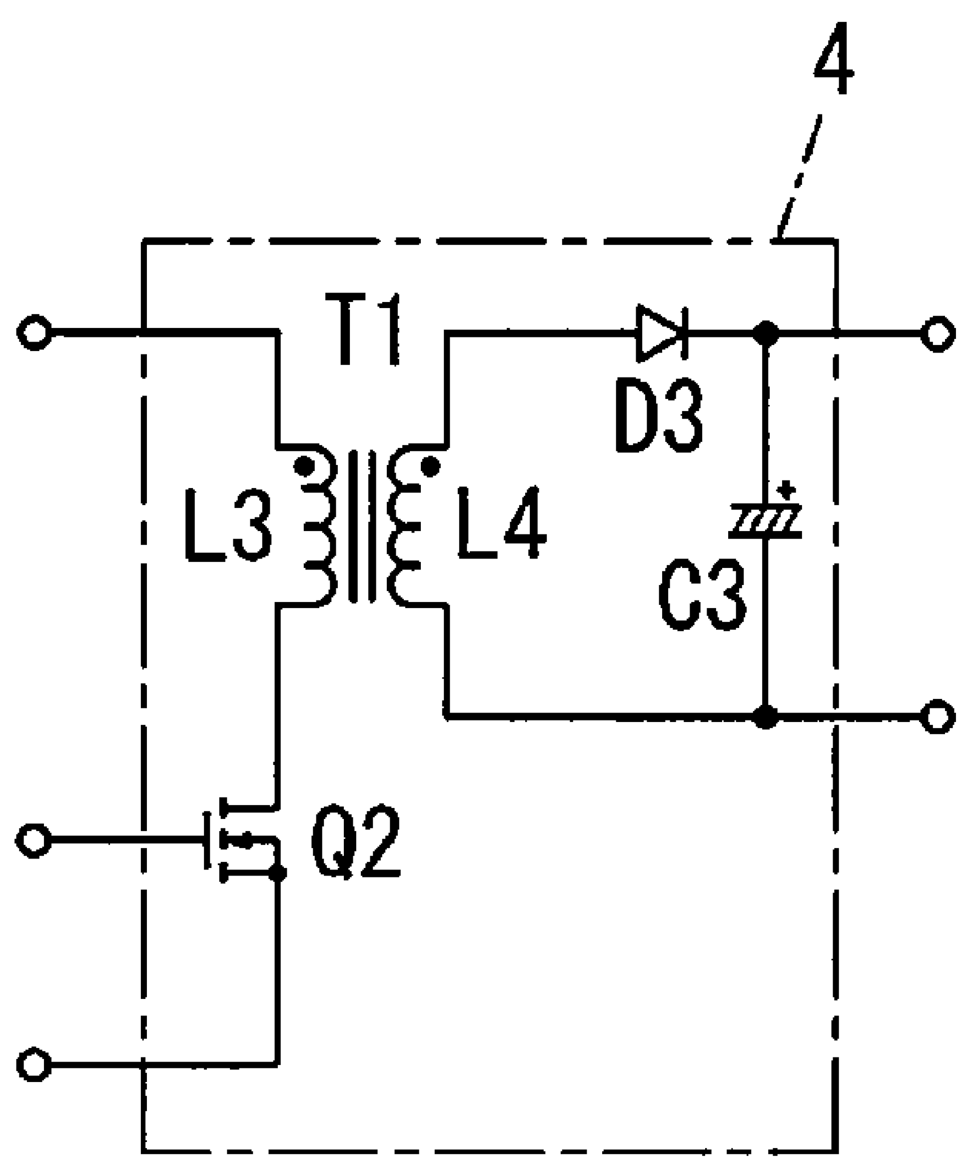


FIG. 2B

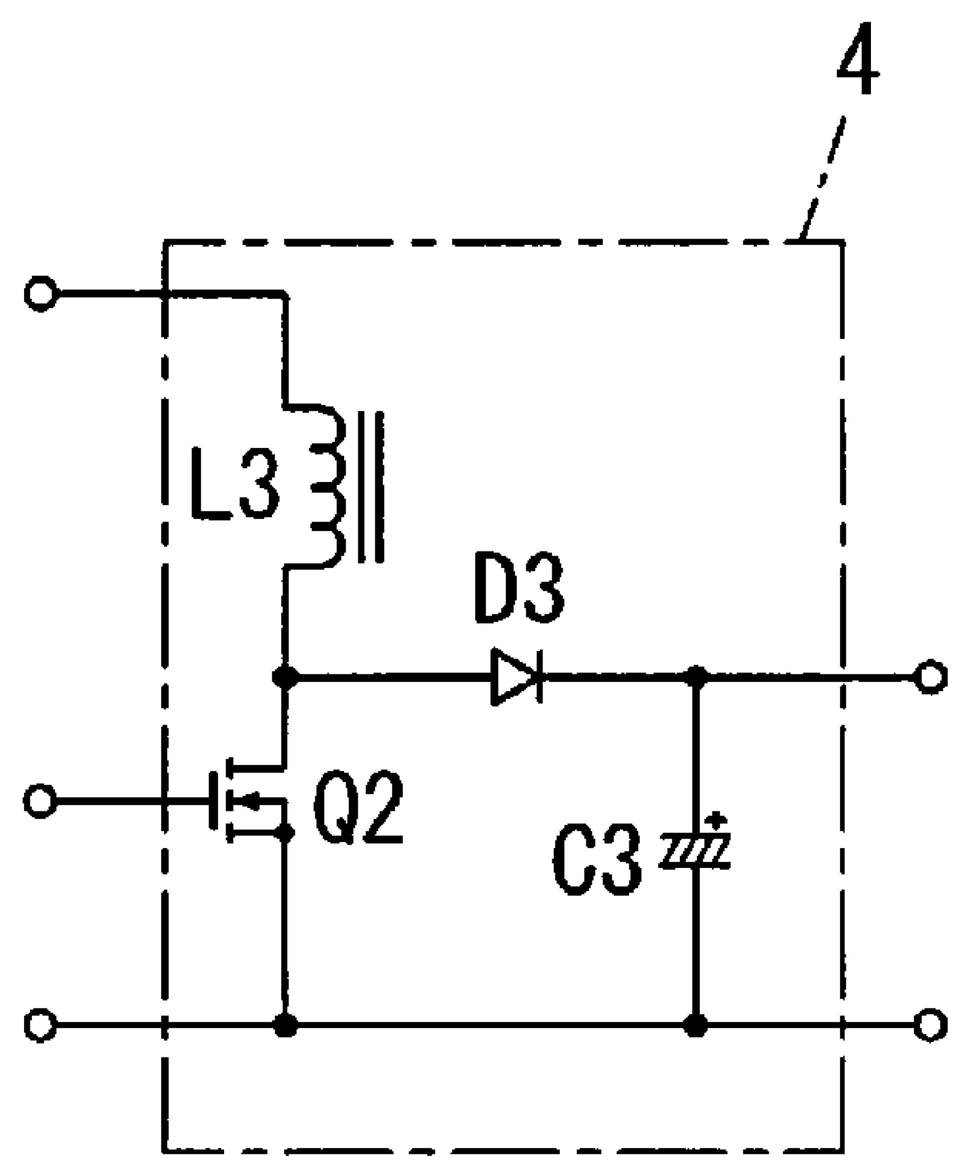


FIG. 2C

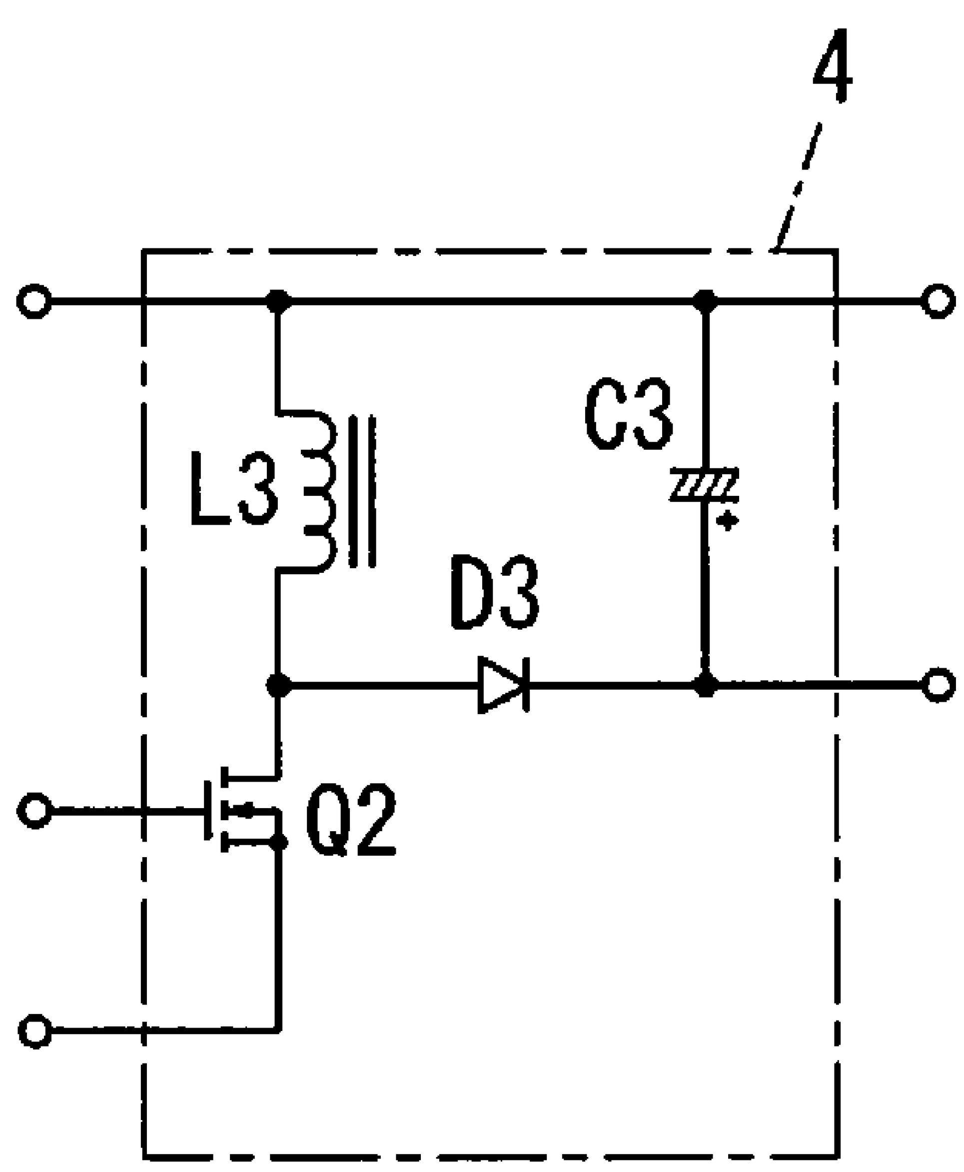


FIG. 2D

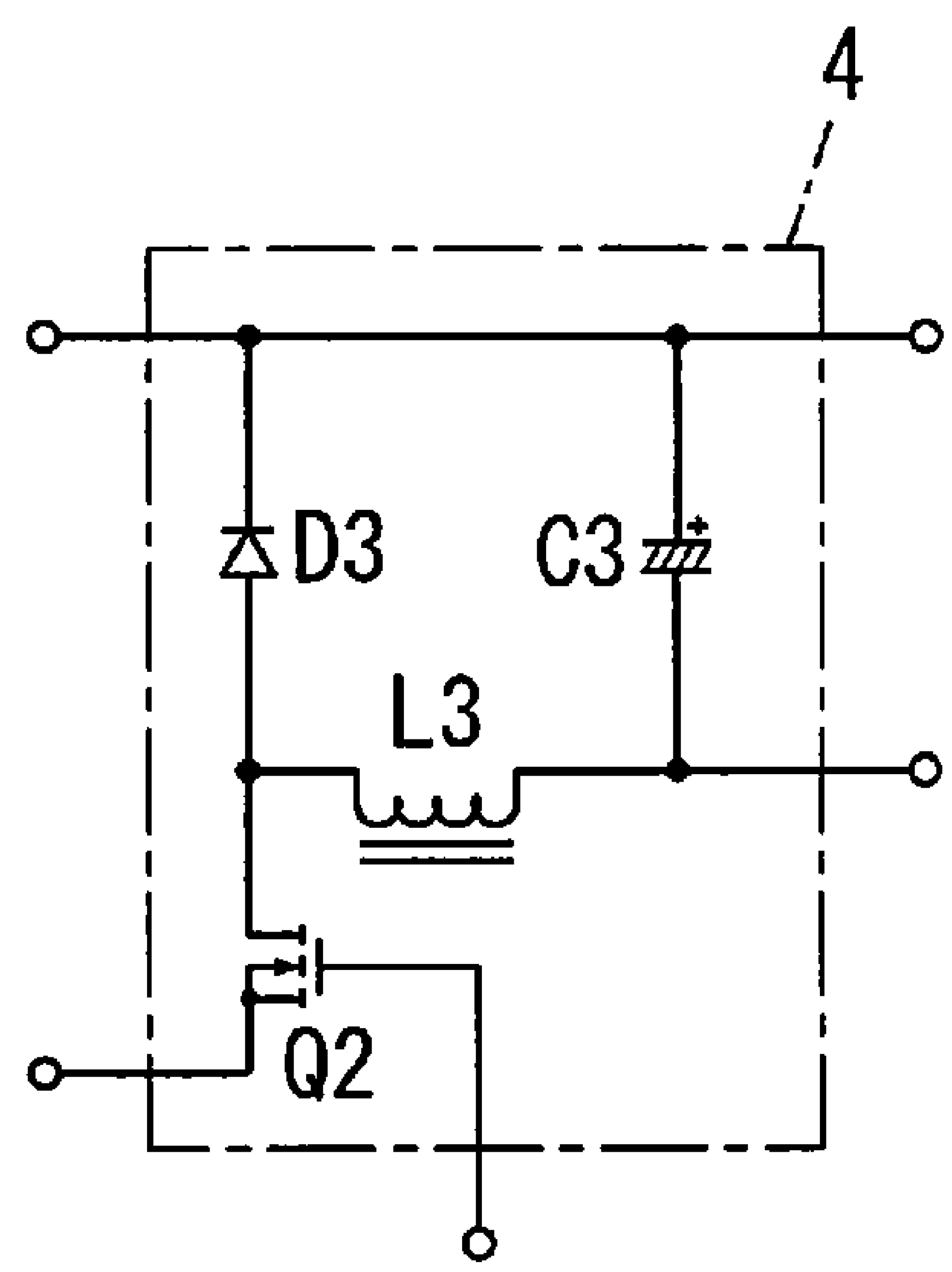
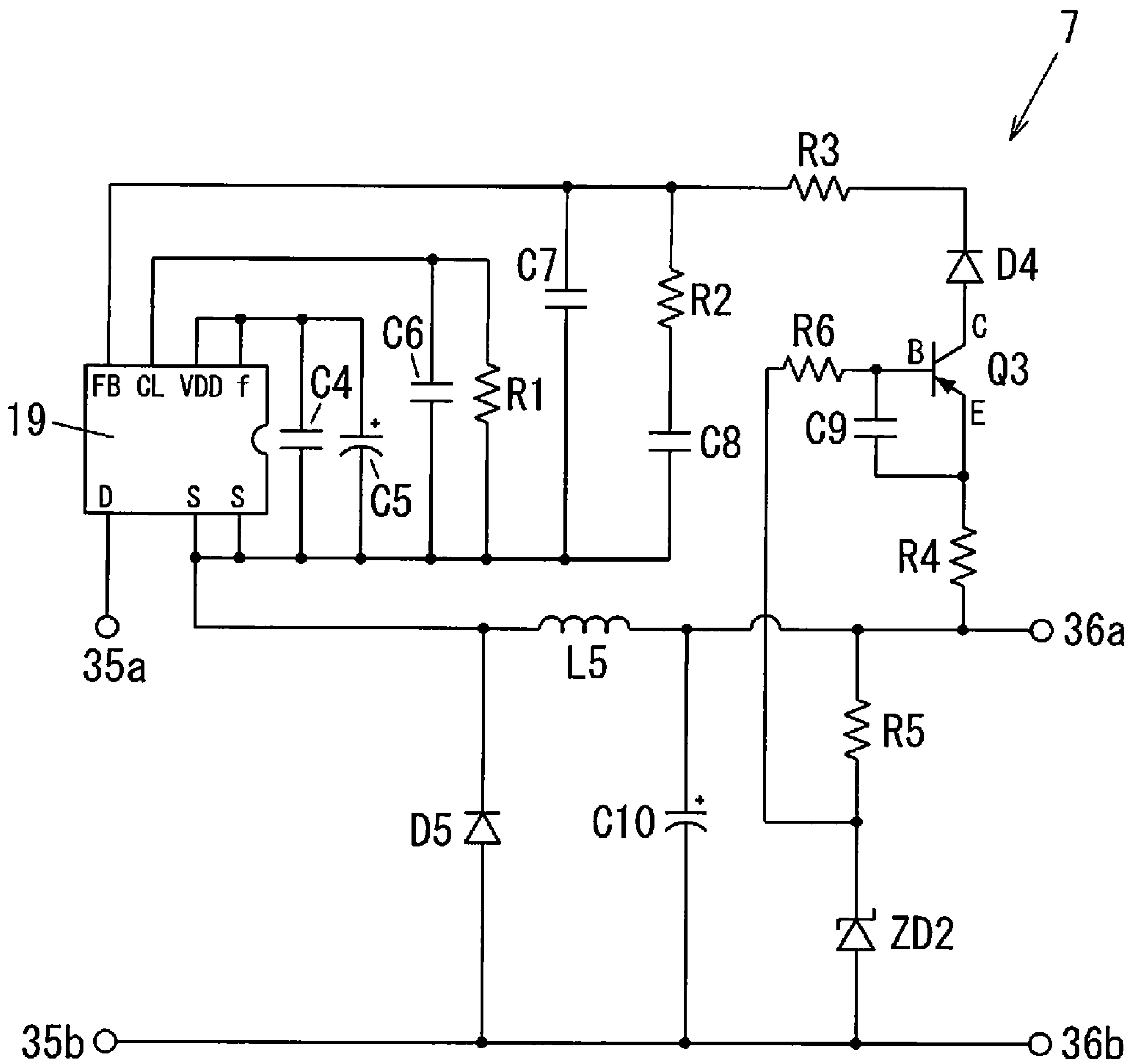


FIG. 3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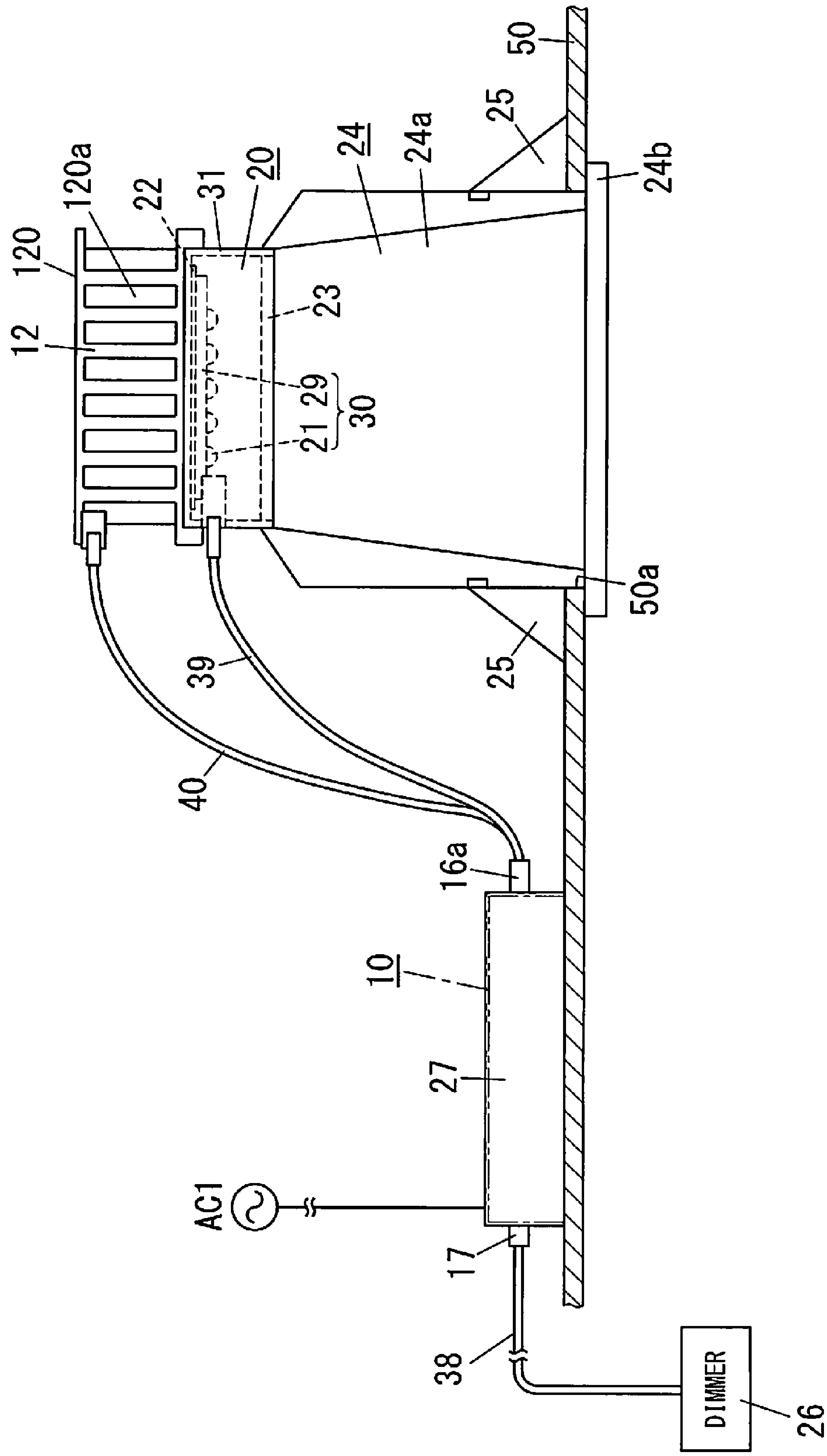
D4
C7
R2
C6
R6
C
B
Q3
E
19
FB CL VDD f
C4
R1
C9
C8
C5
D S S
R4
35a
L5
36a
R5
D5
C10
ZD2
35b
36b

FIG. 4



120
120a
22
31
20
24
24a
25
50
24b
12
23
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21
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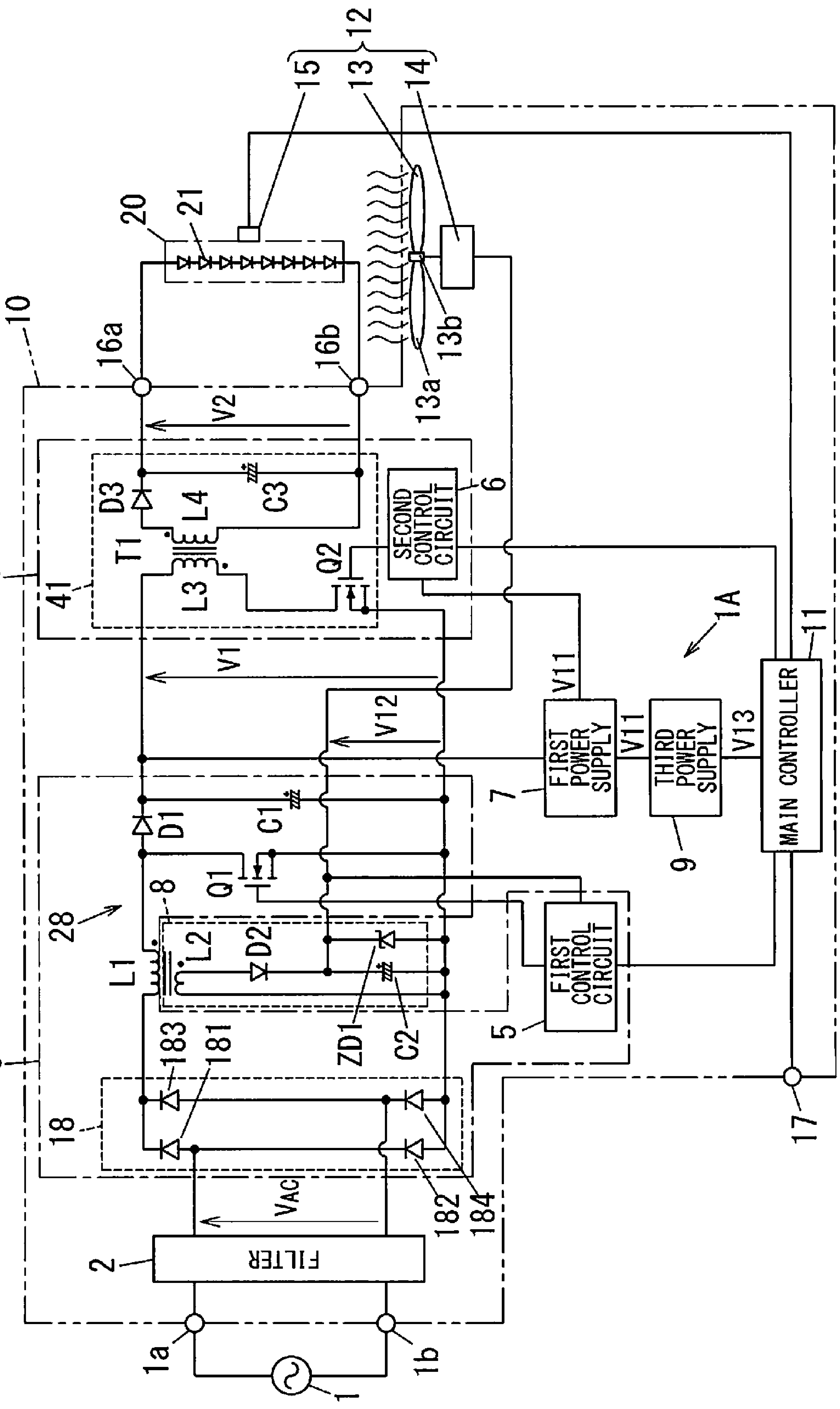
50a
25
39
40
16a
10
27
AC1
17
38
DIMMER
26

FIG. 5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FIRST POWER SUPPLY
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MAIN CONTROLLER
VAC
V1
V2
V11
V12
V13
L1
L2
L3
L4
T1
D1
D2
D3
Q1
Q2
C1
C2
C3
ZD1
1
1a
1b
1A
2
3
4
5
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9
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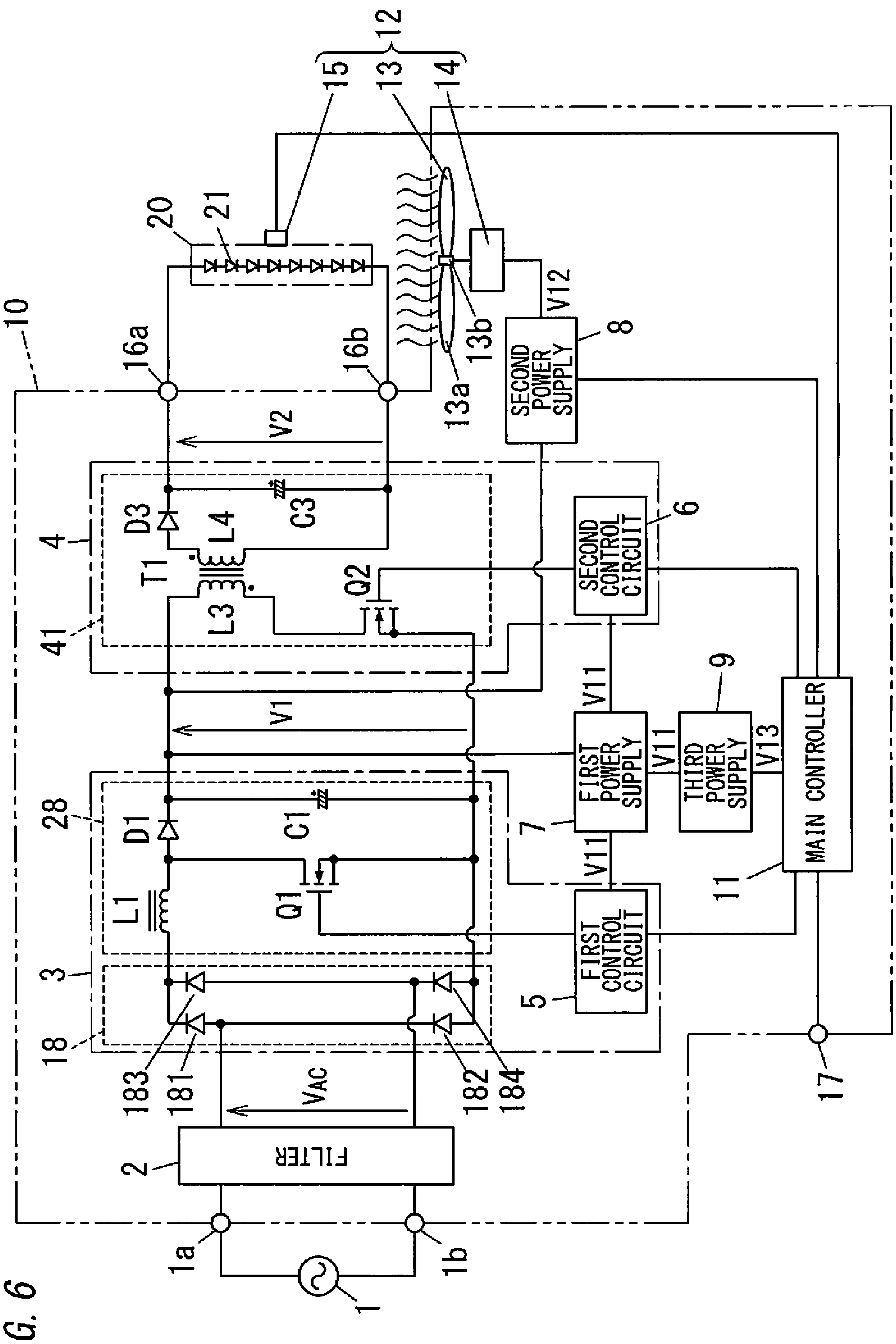
FILTER
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SECOND CONTROL CIRCUIT
FIRST POWER SUPPLY
SECOND POWER SUPPLY
THIRD POWER SUPPLY
MAIN CONTROLLER
V11
V12
V13
V1
V2
VAC
L1
Q1
D1
C1
L3
L4
T1
Q2
D3
C3
1
1a
1b
2
3
4
5
6
7
8
9
10
11
12
13
13a
13b
14
15
16a
16b
17
18
20
21
28
41
181
182
183
184

FIG. 6

ELECTRONIC BALLAST AND LUMINAIRE WITH THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit and priority of Japanese Patent Application No. 2013-164306, filed on Aug. 7, 2013, entitled "ELECTRONIC BALLAST AND LUMINAIRE WITH THE SAME", and Japanese Patent Application No. 2013-164307, filed on Aug. 7, 2013, entitled "ELECTRONIC BALLAST AND LUMINAIRE WITH THE SAME", the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

This disclosure relates generally to electronic ballasts and luminaires and, more particularly, to an electronic ballast (a lighting device) for a light source that includes at least a solid-state light-emitting device, and a luminaire with the same.

BACKGROUND ART

Light emitting modules with LEDs (light-emitting diodes) have been provided as a light source for a luminaire in recent years.

In general, a light emitting module has a tendency to decrease an output of the light emitting module and shorten useful life of the light emitting module as a result of rise in LEDs' temperature. It is therefore important to prevent LEDs' temperature from rising in order to prolong the useful life of the light emitting module in a luminaire with the light emitting module. A luminaire with a light emitting module including LEDs to be driven with high-power requires further preventing LEDs' temperature from rising.

For example, JP Pub. No. 2011-150936 (hereinafter referred to as "Document 1") discloses an LED lighting device having a cooling means such as a fan, and a lighting device.

The LED lighting device described in Document 1 includes LED series circuits and a cooling means driver. The series circuits are connected between output terminals of a DC power supply. The cooling means driver is connected between both ends of a part of the series circuits, including at least one or more LEDs, and configured to cool heat generated by the LEDs. The LED lighting device can effectively prevent its own LEDs' temperature from rising.

A stable voltage can be secured without specially providing the cooling means driver with a power supply. In a case where a fan is employed as a cooling means, the cooling means driver is to drive a fan motor. In this case, the cooling means driver requires a DC voltage of about 6V as DC power for driving the fan motor, and is accordingly supplied with a sum of forward voltages of two LEDs in the series circuit, namely a stable DC voltage of about 6V.

In the LED lighting device of Document D**1**, there is however difficulty in further preventing LEDs' temperature from rising because only a DC voltage of about 6V is supplied to the fan motor of the cooling means driver.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electronic ballast (an LED ballast) capable of supplying a stable

voltage to a cooling device and further preventing light source's temperature from rising, and a luminaire with the same.

According to an aspect of the present invention, an electronic ballast (**10**) comprises an AC-DC converter (**3**), a DC-DC converter (**4**), a cooling device (**12**) and a power supply (**1**A). The AC-DC converter (**3**) comprises a chopper circuit (**28**) configured to convert an AC voltage (V_{AC}) from a commercial power supply (**1**) into a first DC voltage (V**1**). The DC-DC converter (**4**) comprises a DC-DC conversion circuit (**41**) configured to convert the first DC voltage (V**1**) into a second DC voltage (V**2**) to supply the second DC voltage (V**2**) to a light source (**20**) including at least a solid-state light-emitting device (**21**). The cooling device (**12**) is configured to cool the light source (**20**). The power supply (**1**A) comprises a first power supply (**7**) and a second power supply (**8**). The first power supply (**7**) is configured to generate a first operating voltage (V**11**) from a first voltage obtained from the chopper circuit (**28**) to supply the first operating voltage (V**11**) to at least one of the AC-DC converter (**3**) and the DC-DC converter (**4**). The second power supply (**8**) is configured to generate a second operating voltage (V**12**) from a second voltage obtained from the chopper circuit (**28**) to supply the second operating voltage (V**12**) to at least the cooling device (**12**) of the AC-DC converter (**3**), the DC-DC converter (**4**) and the cooling device (**12**).

According to an aspect of the present invention, a luminaire comprises a light source (**20**) including at least a solid-state light-emitting device (**21**); and an electronic ballast (**10**). The electronic ballast (**10**) comprises an AC-DC converter (**3**), a DC-DC converter (**4**), a cooling device (**12**) and a power supply (**1**A). The AC-DC converter (**3**) comprises a chopper circuit (**28**) configured to convert an AC voltage (V_{AC}) from a commercial power supply (**1**) into a first DC voltage (V**1**). The DC-DC converter (**4**) comprises a DC-DC conversion circuit (**41**) configured to convert the first DC voltage (V**1**) into a second DC voltage (V**2**) to supply the second DC voltage (V**2**) to the light source (**20**). The cooling device (**12**) is configured to cool the light source (**20**). The power supply (**1**A) comprises a first power supply (**7**) and a second power supply (**8**). The first power supply (**7**) is configured to generate a first operating voltage (V**11**) from a first voltage obtained from the chopper circuit (**28**) to supply the first operating voltage (V**11**) to at least one of the AC-DC converter (**3**) and the DC-DC converter (**4**). The second power supply (**8**) is configured to generate a second operating voltage (V**12**) from a second voltage obtained from the chopper circuit (**28**) to supply the second operating voltage (V**12**) to at least the cooling device (**12**) of the AC-DC converter (**3**), the DC-DC converter (**4**) and the cooling device (**12**).

In the present invention, it is possible to supply a stable voltage to a cooling device and further prevent light source's temperature from rising.

BRIEF DESCRIPTION OF THE DRAWINGS

The figures depict one or more implementations in accordance with the present teaching, by way of example only, not bay way of limitations. In the figure, like reference numerals refer to the same or similar elements where:

FIG. **1** exemplifies a schematic circuit diagram of an electronic ballast in accordance with an embodiment of the present invention;

FIGS. **2**A to **2**D exemplify other configurations of a DC-DC converter in the electronic ballast;

FIG. **3** exemplifies a circuit diagram of a first power supply in the electronic ballast;

FIG. **4** exemplifies a schematic diagram of luminaire with the electronic ballast;

FIG. **5** exemplifies a schematic circuit diagram of an electronic ballast in accordance with an embodiment of the present invention; and

FIG. **6** exemplifies a schematic circuit diagram of an electronic ballast in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

An electronic ballast (an LED ballast) **10** in accordance with an embodiment of the present invention is now explained with reference to FIGS. **1** to **3**. For example, the electronic ballast **10** is configured to operate a light source **20** including one or more solid-state light-emitting devices **21**. In the embodiment, the light source **20** includes solid-state light-emitting devices **21**.

In an example of FIG. **1**, the light source **20** has eight solid-state light-emitting devices **21**. In the embodiment, light-emitting diodes (LEDs) are employed as the solid-state light-emitting devices **21**, and light emission color thereof is set to white. In the example of FIG. **1**, a connection configuration of the solid-state light-emitting devices **21** is a series connection, but the invention is not limited to this. As an embodiment of the invention, the connection configuration may be a parallel connection or a combination of a series connection and a parallel connection.

The electronic ballast **10** includes a filter **2**, an AC-DC converter **3**, a DC-DC converter **4**, a power supply **1**A, a cooling device **12** and a main controller **11**. The filter **2** is configured to remove noise (e.g., noise from and/or to a commercial power supply **1**).

The AC-DC converter **3** includes a chopper circuit **28** that is configured to convert an AC (alternating current) voltage V_{AC} from the commercial power supply **1** into a first DC (direct current) voltage V**1**. In the example of FIG. **1**, the AC-DC converter **3** includes a full-wave rectifier **18** and a first control circuit **5** in addition to the chopper circuit **28**.

The DC-DC converter **4** includes a DC-DC conversion circuit **41** that is configured to convert the first DC voltage V**1** into a second DC voltage V**2** to supply the second DC voltage V**2** to the light source **20**. In the example of FIG. **1**, the DC-DC converter **4** includes a second control circuit **6** in addition to the DC-DC conversion circuit **41**.

In the embodiment, the first DC voltage V**1** and the second DC voltage V**2** are set to, for example, 410V and 150V, respectively.

The first control circuit **5** is configured to control the chopper circuit **28** of the AC-DC converter **3**. The second control circuit **6** is configured to control the DC-DC conversion circuit **41** of the DC-DC converter **4**.

The power supply **1**A includes a first power supply **7** and a second power supply **8**. The first power supply **7** is configured to generate a first operating voltage V**11** from a first voltage obtained from the chopper circuit **28** to supply the first operating voltage V**11** to at least one of the AC-DC converter **3** and the DC-DC converter **4**. The second power supply **8** is configured to generate a second operating voltage V**12** from a second voltage obtained from the chopper circuit **28** to supply the second operating voltage V**12** to at least the cooling device **12** of the AC-DC converter **3**, the DC-DC converter **4** and the cooling device **12**.

In the example of FIG. **1**, the first power supply **7** is configured to supply the first operating voltage V**11** to the AC-DC converter **3** and the DC-DC converter **4**. Specifically, the first power supply **7** is configured to generate the first operating voltage V**11** for the first control circuit **5** and the second control circuit **6** from the first voltage to supply the first operating voltage V**11** to the first control circuit **5** and the second control circuit **6**, where the first voltage is the first DC voltage V**1**. In the embodiment, the first operating voltage V**11** is set to, for example, 12V. The second power supply **8** is configured to generate the second operating voltage V**12** for the cooling device **12** from the second voltage to supply the second operating voltage V**12** to the cooling device **12**.

In the example of FIG. **1**, the power supply **1**A further includes a third power supply **9**. The third power supply **9** is configured to generate a third operating voltage V**13** for the main controller **11** from an output of the first power supply **7** (the first operating voltage V**11**) to supply the third operating voltage V**13** to the main controller **11**. In the embodiment, the third operating voltage V**13** is set to, for example, a voltage in a range of 3-5V.

The cooling device **12** is configured to cool the light source **20** to be connected to an output side of the DC-DC converter **4**. In the example of FIG. **1**, the cooling device **12** is formed of a rotor (an impeller) **13**, a driver **14** and a temperature sensor **15**.

The main controller **11** is configured to individually control the first control circuit **5** and the second control circuit **6**.

The electronic ballast **10** also includes a pair of power input terminals **1***a* and **1***b*, first and second power output terminals **16***a* and **16***b*, and a signal input terminal **17** configured to receive a signal from an outside (a dimming signal). In the example of FIG. **1**, the first power output terminal **16***a* and the second power output terminal **16***b* are a positive output terminal and a negative output terminal, respectively.

Hereinafter, each component of the electronic ballast **10** is explained in details.

The filter **2** may be formed of, for example, a filter circuit including a common mode filter formed of at least one capacitor (not shown) and first and second inductors (not shown). For example, a first end of the first inductor is connected to a side of the power input terminal **1***a*, and a first end of the second inductor is connected to a side of the power input terminal **1***b*. The capacitor is connected between the first ends or second ends of the first and second inductors. In this case, the first ends of the first and second inductors constitute a pair of input ends of the filter **2**, and the second ends of the first and second inductors constitute a pair of output ends of the filter **2**.

The pair of input ends of the filter **2** is electrically connected to the commercial power supply **1** through the pair of power input terminals **1***a* and **1***b*. In the example of FIG. **1**, the pair of input ends of the filter **2** is individually connected to the pair of power input terminals **1***a* and **1***b*, and the commercial power supply **1** is connected between the pair of power input terminals **1***a* and **1***b*. In the embodiment, a switch (not shown) configured to make or break an electrical connection between the commercial power supply **1** and the electronic ballast **10** is provided along a power supply line between the commercial power supply **1** and one of the pair of power input terminals **1***a* and **1***b*. In this case, the commercial power supply **1** is not included in a component of the electronic ballast **10**.

For example, a diode bridge may be employed as the full-wave rectifier **18** of the AC-DC converter **3**. In the example of FIG. **1**, diodes **181** to **184** constitute the diode bridge. Specifically, a first end of the diode **181** and a first end of the diode **183** are connected and constitute a positive output end of the full-wave rectifier **18**. A second end of the diode **181** and a first end of the diode **182** are connected and constitute an input end of the full-wave rectifier **18**. A second end of the diode **183** and a first end of the diode **184** are connected and constitute another input end of the full-wave rectifier **18**. A second end of the diode **182** and a second end of the diode **184** are connected and constitute a negative output end of the full-wave rectifier **18**. In this example, each first end of the diodes **181** to **184** is a cathode, and each second end is an anode. In short, the full-wave rectifier **18** has a pair of input ends, and the positive and negative output ends. The pair of input ends of the full-wave rectifier **18** is individually connected to the pair of output ends of the filter **2**.

For example, a boost chopper circuit (a boost converter) may be employed as the chopper circuit **28**. The chopper circuit **28** includes a switching device Q**1** and is configured so that the switching device Q**1** is turned on and off in accordance with control (a control signal) of the first control circuit **5** and thereby an AC voltage from the commercial power supply **1** is increased to the first DC voltage V**1**.

In the example of FIG. **1**, the chopper circuit **28** includes an inductor L**1**, a diode D**1** and a capacitor C**1** in addition to the switching device Q**1**. The inductor L**1** is formed of a choke coil for chopper.

A first end of the inductor L**1** is connected to the positive output end of the full-wave rectifier **18**. A second end of the inductor L**1** is connected to an anode side of the diode D**1**. A cathode of the diode D**1** is connected to a positive side (i.e., a positive electrode side) of the capacitor C**1**. A negative side (i.e., a negative electrode side) of the capacitor C**1** is connected to the negative output end of the full-wave rectifier **18**. Both ends of the capacitor C**1** constitute output ends of the AC-DC converter **3**.

For example, an N-channel MOSFET that is normally off may be employed as the switching device Q**1**. A first end of the switching device Q**1** (a drain terminal in the example of FIG. **1**) is connected to the anode side of the diode D**1**. A second end of the switching device Q**1** (a source terminal in the example) is connected to the negative side of the capacitor C**1**. A control terminal of the switching device Q**1** (a gate terminal in the example) is connected to the first control circuit **5**.

The second power supply **8** includes an inductor L**2** as a secondary winding magnetically coupled to the inductor L**1** as a primary winding in the chopper circuit **28**, and the aforementioned second voltage is obtained from the inductor L**2**.

In the example of FIG. **1**, the second power supply **8** includes a diode D**2**, a capacitor C**2** and a Zener diode ZD**1** in addition to the inductor L**2**. A first end of the inductor L**2** is connected to the negative output end of the full-wave rectifier **18**. A second end of the inductor L**2** is connected to an anode side of the diode D**2**. A cathode of the diode D**2** is connected to a positive side of the capacitor C**2**. A negative side of the capacitor C**2** is connected to the negative output end of the full-wave rectifier **18**. The Zener diode ZD**1** is provided between both ends of the capacitor C**2**. A cathode of the Zener diode ZD**1** is connected to the positive side of the capacitor C**2**. An anode of the Zener diode ZD**1** is connected to the negative side of the capacitor C**2**.

For example, a flyback converter may be employed as the DC-DC converter **4**. The DC-DC conversion circuit **41** of the DC-DC converter **4** includes a switching device Q**2** and is configured so that the switching device Q**2** is turned on and off in accordance with control (a control signal) of the second control circuit **6** and thereby an output (the first DC voltage V**1**) of the AC-DC converter **3** is decreased to the second DC voltage V**2**.

In the example of FIG. **1**, the DC-DC conversion circuit **41** includes a transformer T**1**, a diode D**3** and a capacitor C**3** in addition to the switching device Q**2**. For example, an N-channel MOSFET that is normally off may be employed as the switching device Q**2**. The transformer T**1** includes an inductor L**3** as a primary winding and an inductor L**4** as a secondary winding.

A first end of the inductor L**3** in the transformer T**1** is connected to a side of the positive output end of the AC-DC converter **3**, namely the positive side of the capacitor C**1**. A second end of the inductor L**3** is connected to a first end of the switching device Q**2** (a drain terminal in the example of FIG. **1**). A second end of the switching device Q**2** (a source terminal in the example) is connected to a side of the negative output end of the AC-DC converter **3** (the negative side of the capacitor C**1**). A control terminal of the switching device Q**2** (a gate terminal in the example) is connected to the second control circuit **6**.

A first end of the inductor L**4** in the transformer T**1** is connected to an anode side of the diode D**3**. A cathode of the diode D**3** is connected to a positive side of the capacitor C**3**. A negative side of the capacitor C**3** is connected to a second end of the inductor L**4**. Both ends of the capacitor C**3** constitute output ends of the DC-DC converter **4**.

A side of the positive output end of the DC-DC converter **4** (the positive side of the capacitor C**3**) is connected to a first end (an anode) of the light source **20** through the first power output terminal **16***a*. A side of the negative output end of the DC-DC converter **4** (the negative side of the capacitor C**3**) is connected to a second end (a cathode) of the light source **20** through the second power output terminal **16***b*.

In the electronic ballast **10** of the embodiment, a voltage across the capacitor C**3** as the second DC voltage V**2** (an output voltage of the DC-DC converter **4**) is to be applied across the light source **20** through the first and second power output terminals **16***a* and **16***b*. Thus, the light source **20** can operate by the output voltage of the DC-DC converter **4**.

In the embodiment, the DC-DC conversion circuit **41** of the DC-DC converter **4** is formed of the flyback converter, but not limited to this. Examples of the DC-DC conversion circuit **41** include a forward converter as shown in FIG. **2**A, a boost chopper circuit (a boost converter) as shown in FIG. **2**B, a boost/buck chopper circuit (a boost/buck converter) as shown in FIG. **2**C, and a buck chopper circuit (a buck converter) as shown in FIG. **2**D.

In the forward converter of FIG. **2**A, a first end of an inductor L**3** is connected to the positive side of the capacitor C**1** in the AC-DC converter **3**. A second end of the inductor L**3** is connected to a drain terminal of a switching device Q**2**. A source terminal of the switching device Q**2** is connected to the negative side of the capacitor C**1**. A gate terminal of the switching device Q**2** is connected to the second control circuit **6**. A first end of an inductor L**4** is connected to an anode side of a diode D**3**. A cathode of the diode D**3** is connected to a positive side of a capacitor C**3**. A negative side of the capacitor C**3** is connected to a second end of the inductor L**4**. The positive and negative sides of the capacitor C**3** are connected to the first and second power output terminals **16***a* and **16***b*, respectively.

In the boost chopper circuit of FIG. **2**B, a first end of an inductor L**3** is connected to the positive side of the capacitor C**1** in the AC-DC converter **3**. A second end of the inductor L**3** is connected to a drain terminal of a switching device Q**2**. The drain terminal of the switching device Q**2** is connected to an anode side of a diode D**3**. A cathode of the diode D**3** is connected to a positive side of a capacitor C**3**. A negative side of the capacitor C**3** is connected to a source terminal of the switching device Q**2**. A source terminal of the switching device Q**2** is connected to the negative side of the capacitor C**1**. A gate terminal of the switching device Q**2** is connected to the second control circuit **6**. The positive and negative sides of the capacitor C**3** are connected to the first and second power output terminals **16***a* and **16***b*, respectively.

In the boost/buck chopper circuit of FIG. **2**C, a first end of an inductor L**3** is connected to the positive side in the AC-DC converter **3**. A second end of the inductor L**3** is connected to a drain terminal of a switching device Q**2**. A source terminal of the switching device Q**2** is connected to the negative side of the capacitor C**1**. A gate terminal of the switching device Q**2** is connected to the second control circuit **6**. A first end of the inductor L**3** is connected to a negative side of a capacitor C**3**. A positive side of the capacitor C**3** is connected to a cathode of a diode D**3**. An anode side of the diode D**3** is connected to a second end of the inductor L**3**. The positive and negative sides of the capacitor C**3** are connected to the first and second power output terminals **16***a* and **16***b*, respectively.

In the buck chopper circuit of FIG. **2**D, a cathode of a diode D**3** is connected to the positive side of the capacitor C**1** in the AC-DC converter **3**. An anode side of a diode D**3** is connected to a drain terminal of a switching device Q**2**. A source terminal of the switching device Q**2** is connected to the negative side of the capacitor C**1**. A gate terminal of the switching device Q**2** is connected to the second control circuit **6**. The cathode of the diode D**3** is connected to a positive side of a capacitor C**3**. A negative side of the capacitor C**3** is connected to a first end of an inductor L**3**. A second end of the inductor L**3** is connected to an anode side of the diode D**3**. The positive and negative sides of the capacitor C**3** are connected to the first and second power output terminals **16***a* and **16***b*, respectively.

The first control circuit **5** may be formed of, for example, a control IC (integrated circuit). As a concrete example, the control IC of the first control circuit **5** may be, but not limited to, a control IC such as FA5501A control IC for power factor correction, manufactured by Fuji Electric.

The first control circuit **5** is configured to control ON and OFF (switching) of the switching device Q**1** in the chopper circuit **28** of the AC-DC converter **3**.

The second control circuit **6** may be formed of, for example, a control IC. As a concrete example, the control IC of the second control circuit **6** may be, but not limited to, a control IC such as FA5546 control IC for PWM (pulse width modulation) control, manufactured by Fuji Electric.

The second control circuit **6** is configured to control ON and OFF (switching) of the switching device Q**2** in the DC-DC conversion circuit **41** of the DC-DC converter **4**.

The first power supply **7** may be formed of, for example, a power supply IC. As a concrete example, the power supply IC of the first power supply **7** may be, but not limited to, MIP3530MS Intelligent Power Device (hereinafter referred to as "IPD"), manufactured by Panasonic.

As shown in FIG. **3**, the first power supply **7** includes an IPD **19**, six resistors R**1** to R**6**, seven capacitors C**4** to C**10**, an inductor L**5**, two diodes D**4** and D**5**, a switching device Q**3** and a Zener diode ZD**2**. In addition, the first power supply **7** includes first and second input terminals **35***a* and **35***b*, and first and second output terminals **36***a* and **36***b*. In an example of FIG. **3**, a PNP bipolar transistor is employed as the switching device Q**3**.

As shown in FIG. **3**, pin #1 of the IPD **19**, depicted by "f" is connected to pin #2 of the IPD **19**, depicted by "VDD". Pin #1 and pin #2 of the IPD **19** are connected to pin #7 and pin #8 of the IPD **19**, depicted by two "S" through a parallel circuit of the capacitors C**4** and C**5**. Pin #3 of the IPD **19**, depicted by "CL" is connected to pin #7 and #8 of the IPD **19** through a parallel circuit of the capacitor C**6** and the resistor R**1**. Pin #4 of the IPD **19**, depicted by "FB" is connected to pin #7 and #8 of the IPD **19** through a parallel circuit of the capacitor C**7** and a series circuit of the resistor R**2** and the capacitor C**8**. The resistor R**2** is connected to pin #4 of the IPD **19**, and the capacitor C**8** is connected to pin #7 and pin #8 of the IPD **19**.

An end of the resistor R**2** connected to pin #4 of the IPD **19** is connected to a cathode side of the diode D**4** through the resistor R**3**. An anode side of the diode D**4** is connected to a first end (a collector terminal in the example of FIG. **3**) of the switching device Q**3**. A second terminal (an emitter terminal in the example) of the switching device Q**3** is connected to the first output terminal **36***a* through the resistor R**4**. A control terminal (a base terminal in the example) of the switching device Q**3** is connected to the emitter terminal of the switching device Q**3** through the capacitor C**9**. A series circuit of the resistor R**5** and the Zener diode ZD**2** is connected between the first and second output terminals **36***a* and **36***b*. An anode side of the Zener diode ZD**2** is connected to the second output terminal **36***b*. A cathode side of the Zener diode ZD**2** is connected to the resistor R**5**. The base terminal of the switching device Q**3** is connected to a junction of the resistor R**5** and the Zener diode ZD**2** through the resistor R**6**.

The series circuit of the resistor R**5** and the Zener diode ZD**2** is connected in parallel with the capacitor C**10**. A positive side of the capacitor C**10** is connected to one end of the resistor R**5** connected to the first output terminal **36***a*. A negative side of the capacitor C**10** is connected to the anode of the Zener diode ZD**2** connected to the second output terminal **36***b*. The positive side of the capacitor C**10** is connected to a cathode of the diode D**5** through the inductor L**5**. The negative side of the capacitor C**10** is connected to an anode of the diode D**5**. The cathode side of the diode D**5** is connected to pin #7 and pin #8 of the IPD **19**. The anode side of the diode D**5** is connected to the second input terminal **35***b*. The first input terminal **35***a* is connected to pin #5 of the IPD **19**, depicted by "D".

In the embodiment, the first input terminal **35***a* is connected to the positive side of the capacitor C**1** in the AC-DC converter **3**, and the second input terminal **35***b* is connected to the negative side of the capacitor C**1**. In the example of FIG. **1**, the first output end **36***a* is connected to the first control circuit **5**, the second control circuit **6** and the third power supply **9**, and the second output terminal **36***b* is connected to a common ground (not shown) of the first control circuit **5** and the second control circuit **6**.

The first power supply **7** is configured to generate the first operating voltage V**11** from a voltage across the capacitor C**1** (an output voltage of the AC-DC converter **3**) as the first DC voltage V**1**, and to supply the first operating voltage V**11** to the first control circuit **5**, the second control circuit **6** and the third power supply **9**.

The cooling device **12** may be formed of an air cooling device (e.g., an axial flow fan). In the example of FIG. **1**, the cooling device **12** includes the rotor (the impeller) **13** and the driver **14**. The rotor (the impeller) **13** includes vanes **13***a*, and a rotation axis **13***b* to which the vanes **13***a* are attached, and is configured so that the vanes **13***a* are free to rotate clockwise or counterclockwise around the rotation axis **13***b*. The driver **14** is configured to drive the rotor **13**. For example, the driver **14** is formed of a DC motor, and connected to the positive side of the capacitor C**2** in the second power supply **8**. In the embodiment, the driver **14** is formed of the DC motor, but the invention is not limited to this. As an embodiment of the invention, the driver **14** may be formed of a pulse motor or the like. In this case, it is possible to suitably set a rotation speed of the rotor **13** and to adjust cooling capability of the cooling device **12**. In the example of FIG. **1**, the cooling device **12** is formed of the air cooling device, but is not limited to this. Examples of the cooling device **12** include a water cooling device configured to circulate water with a pump, a Peltier cooling device with Peltier element, and the like.

The cooling device **12** is configured to operate by receiving electric power from the inductor L**2** as the secondary winding magnetically coupled to the inductor L**1** as the primary winding in the chopper circuit **28**. That is, in the electronic ballast **10**, a first voltage (an induced voltage) induced across the inductor L**2** is to be applied across the capacitor C**2** through the diode D**2**. A voltage across the capacitor C**2** is to be then supplied as the second operating voltage V**12** to the driver **14**. In the example of FIG. **1**, the diode D**2** and the capacitor C**2** constitute a rectifier smoothing circuit configured to rectify the first voltage induced across the inductor L**2** and also to remove the ripples therefrom. In the embodiment, the first voltage induced across the inductor L**2** is set to, for example, a voltage in a range of 5 to 12V.

It is therefore possible to supply the driver **14** with the second operating voltage V**12** obtained from the first voltage induced across the inductor L**2** to operate the cooling device **12**. As a result, the electronic ballast **10** can effectively dissipate heat generated in the light source **20**. In the embodiment, the second operating voltage V**12** is set to, for example, a voltage in a range of 5 to 12V.

Since the Zener diode ZD**1** is connected in parallel with the capacitor C**2**, the electronic ballast **10** can prevent the second operating voltage V**12** from exceeding a Zener voltage of the Zener diode ZD**1**. As a result, the electronic ballast **10** prevent malfunction of the cooling device **12**. In the embodiment, the Zener voltage of the Zener diode ZD**1** is set to, for example, 12V.

In the embodiment, the second power supply **8** configured to generate the second operating voltage V**12** for activating only the cooling device **12** is physically separated from the first power supply **7**, and accordingly the electronic ballast **10** can supply a stable voltage to the cooling device **12**. In addition, since the second operating voltage V**12** is supplied from the second power supply **8** to the cooling device **12**, the electronic ballast **10** can further increase the second operating voltage V**12** in comparison with the LED lighting device of Document 1. It is accordingly possible to employ the cooling device **12** having higher cooling capability. As a result, the electronic ballast **10** can further prevent light source's (**20**) temperature from rising in comparison with the LED lighting device of Document 1.

The main controller **11** is formed of, for example, a microcomputer and a suitable program installed in the main controller **11**. The program is stored in a memory unit (not shown) provided in the microcomputer.

The main controller **11** is connected to each of the first control circuit **5** and the second control circuit **6**. That is, the main controller **11** is configured to control ON and OFF of the switching device Q**1** in the chopper circuit **28** through the first control circuit **5** and also to control ON and OFF of the switching device Q**2** in the DC-DC conversion circuit **41** through the second control circuit **6**.

The main controller **11** is also connected with the temperature sensor **15** that is configured to detect (measure) the light source' (**20**) temperature. The temperature sensor **15** may be formed of, for example, a thermistor or the like. For example, the main controller **11** may be configured to activate the cooling device **12** by controlling ON and OFF of the switching device Q**1** in the chopper circuit **28** through the first control circuit **5** if the temperature sensor **15** detects that the light source' (**20**) temperature is a predetermined temperature or more. In this example, heat generated in the light source **20** can be dissipated effectively.

The main controller **11** is further connected to the signal input terminal **17**. In the embodiment, the main controller **11** is configured to receive a dimming signal from the signal input terminal **17**. Examples of the dimming signal include a DALI (Digital Addressable Lighting Interface) signal, a DMX (Digital Multiplex) signal, a PWM (Pulse Width Modulation) signal, a DC (Direct Current) signal, and the like.

The main controller **11** is configured to control the switching device Q**2** in the DC-DC conversion circuit **41** through the second control circuit **6** in accordance with a dimming signal if receiving the dimming signal. Specifically, the main controller **11** is configured to control ON duty ratio of the switching device Q**2** in the DC-DC conversion circuit **41** through the second control circuit **6** in accordance with a dimming signal if receiving the dimming signal. As a result, the electronic ballast **10** can control light output of the light source **20**.

In the embodiment, the main controller **11** is configured, if receiving a dimming signal, to control ON duty ratio of the switching device Q**2** in accordance with the dimming signal, but the invention is not limited to this. As an embodiment of the invention, the main controller **11** may be configured to control OFF duty ratio of the switching device Q**2**.

In the embodiment, the main controller **11** is configured, if receiving a dimming signal, to control the switching device Q**2** through the second control circuit **6** in accordance with the dimming signal, but the invention is not limited to this. As an embodiment of the invention, the main controller **11** may be configured to control the switching device Q**1** through the first control circuit **5** in accordance with a dimming signal. For example, the main controller **11** may be configured, if receiving a dimming signal, to control ON duty ratio or OFF duty ratio of the switching device Q**1** in the chopper circuit **28** through the first control circuit **5** in accordance with the dimming signal. As another example, the main controller **11** may be configured, if receiving a dimming signal, to control the switching devices Q**1** and Q**2** through the first and second control circuits **5** and **6** in accordance with the dimming signal.

The third power supply **9** may be formed of, for example, a three-terminal regulator. For example, the third power supply **9** may be formed of, but not limited to, a device such as S-812C series voltage regulator manufactured by Seiko Instruments.

In the example of FIG. **1**, an input terminal and an output terminal of the third power supply **9** are connected to the first power supply **7** and the main controller **11**, respectively. A ground terminal (not shown) of the third power supply **9** is connected to a ground (not shown) of the electronic ballast **10**.

The third power supply **9** is configured to generate the third operating voltage V**13** from the first operating voltage V**11** of the first power supply **7** to supply the third operating voltage V**13** to the main controller **11**.

In the embodiment, each of the first control circuit **5** and the second control circuit **6** includes a control IC, but the invention is not limited to this. As an embodiment of the invention, each of the first control circuit **5** and the second control circuit **6** may include a microcomputer and a suitable program installed in the microcomputer. As another embodiment, both of the first control circuit **5** and the second control circuit **6** may be formed of one microcomputer.

In the embodiment, the light source **20** includes at least a light-emitting diode as at least a solid-state light-emitting device **21**, but the invention is not limited to this. As an embodiment of the invention, the light source **20** may include an organic electroluminescence element(s), a semiconductor laser element(s) or the like.

As described above, the electronic ballast **10** in the embodiment includes the AC-DC converter **3**, the DC-DC converter **4**, the cooling device **12** and the power supply **1**A. The AC-DC converter **3** includes the chopper circuit **28** and the first control circuit **5**. The chopper circuit **28** is configured to convert an AC voltage V_{AC} from the commercial power supply **1** into a first DC voltage V**1**. The DC-DC converter **4** includes the DC-DC conversion circuit **41** and the second control circuit **6**. The DC-DC conversion circuit **41** is configured to convert the first DC voltage V**1** into a second DC voltage V**2** to supply the second DC voltage V**2** to the light source **20**. The cooling device **12** is configured to cool the light source **20**. The first control circuit **5** is configured to control the chopper circuit **28**. The second control circuit **6** is configured to control the DC-DC conversion circuit **41**. The power supply **1**A includes the first power supply **7** and the second power supply **8**. The first power supply **7** is configured to generate a first operating voltage V**11** from a first voltage obtained from the chopper circuit **28** to supply the first operating voltage V**11** to the first control circuit **5** and the second control circuit **6**. The first voltage is the first DC voltage V**1**. The second power supply **8** is configured to generate a second operating voltage V**12** from a second voltage obtained from the chopper circuit **28** to supply the second operating voltage V**12** to the cooling device **12**. The second power supply **8** includes the inductor L**2** magnetically coupled to the inductor L**1** of the chopper circuit **28**, and the second voltage is obtained from the inductor L**2**. As a result, the electronic ballast **10** in the embodiment can supply a stable voltage (the second operating voltage V**12**) to the cooling device **12**, and further prevent light source's (**20**) temperature from rising.

An example of a luminaire with the electronic ballast **10** in the embodiment is now explained with reference to FIG. **4**.

The luminaire of the embodiment includes the light source **20** and the electronic ballast **10** configured to operate the light source **20**. The light source **20** and the electronic ballast **10** are to be arranged individually, and the luminaire includes a pair of connecting wires **39** and **39** for connecting the light source **20** and a part of the electronic ballast **10**. In FIG. **4**, one of the connecting wires **39** and **39** is seen. It is accordingly possible to downsize the light source **20**.

The light source **20** includes a light emitting module **30** with a mounting substrate **29** on which the solid-state light-emitting devices **21** are mounted, and a case **31** to which the light emitting module **30** is detachably attached. In FIG. **4**, only five solid-state light-emitting devices **21** of the light emitting module **30** are seen.

The mounting substrate **29** may be formed of, for example, a metal-based printed circuit board or the like. Preferably, a planar shape of the mounting substrate **29** is a circular shape, but may be a polygonal shape or the like. In the embodiment, the mounting substrate **29** is formed of the metal-based printed circuit board, but not limited to this. Examples of the mounting substrate **29** include a ceramic substrate, a glass epoxy substrate, a paper phenol substrate and the like.

The light emitting module **30** is attached to the case **31** through an insulation sheet **22** that has electric insulation and thermal conductivity.

For example, the case **31** is shaped like a tube with a top base (e.g., a cylinder with a top base). For example, metal such as aluminum, stainless steel, iron, or the like may be employed as material of the case **31**.

The light emitting module **30** is disposed on an inner surface of the top base of the case **31** through the insulation sheet **22**. As a result, the luminaire of the embodiment can effectively transmit heat generated in the light emitting module **30** to the case **31**.

A diffuser panel **23** configured to diffuse light emitted from the solid-state light-emitting devices **21** is disposed at an opening side of the case **31** (at a lower side in FIG. **4**). For example, the diffuser panel **23** is shaped like a board (e.g., a disc). For example, optically-transparent material such as acrylic resin, glass, or the like may be employed as material of the diffuser panel **23**.

The luminaire of the embodiment includes a fixture body **24** configured to retain the light source **20**.

The fixture body **24** is formed of a tubular side wall **24***a* and a flange **24***b* protruded laterally from a lower edge of the side wall **24***a*. For example, metal such as aluminum, stainless steel, iron, or the like may be employed as material of the fixture body **24**.

An inside of the side wall **24***a* is shaped like a reversed tapered tube such that an aperture area (an inside diameter) of the side wall **24***a* becomes gradually wider (larger) from a top end to a bottom end in the side wall **24***a*. The light source **20** (the case **31**) is disposed at the top end of the side wall **24***a*. In the luminaire of the embodiment, the diffuser panel **23** is disposed at the opening side of the case **31** in the light source **20**, but the invention is not limited to this. As an embodiment of the invention, the diffuser panel **23** may be disposed at a side of the bottom end of the side wall **24***a* in the fixture body **24**.

A pair of mounting brackets **25** and **25** is disposed outside the side wall **24***a* of the fixture body **24**, and configured to hold part of a ceiling panel **50**, around a hole **50***a* cut in the ceiling panel **50**, between the flange **24***b* and the pair of mounting brackets **25** and **25**. With the side wall **24***a* inserted into the hole **50***a* of the ceiling panel **50** such that the flange **24***b* is in contact with a lower surface of the ceiling panel **50** around the hole **50***a*, the part of the ceiling panel **50** is held between the flange **24***b* and the pair of mounting brackets **25** and **25**. As a result, the fixture body **24** is recessed in the ceiling panel **50**.

The luminaire of the embodiment further includes a case **27** that houses components other than the cooling device **12** in the electronic ballast **10**, namely the filter **2**, the AC-DC converter **3**, the DC-DC converter **4**, the power supply **1**A, the main controller **11**, the pair of power input terminal **1***a* and **1***b*, the first and second power output terminals **16***a* and **16***b* and the signal input terminal **17**.

The case **27** is shaped like a box (e.g., a rectangular box). Examples of material of the case **27** include metal, resin and the like. In the example of FIG. **4**, the case **27** is disposed on an upper surface of the ceiling panel **50**.

The signal input terminal **17** is exposed at a first side wall (a left side wall in the example of FIG. **4**) of the case **27**. In the luminaire of the embodiment, the signal input terminal **17** is connected to a dimmer **26** through a connecting cable **38**. The dimmer **26** is configured to output a dimming signal. In the embodiment, a connection means for connecting the electronic ballast **10** and the dimmer **26** is formed of the connecting cable **38**, but may be formed of a communication device using communication media such as infrared or radio wave.

The first and second power output terminals **16***a* and **16***b* are exposed at a second side wall (a right side wall in the example of FIG. **4**) of the case **27**. In the luminaire of the embodiment, the first and second power output terminals **16***a* and **16***b* are connected to the light source **20** through a pair of connecting wires **39** and **39**. In the example of FIG. **4**, one of the first and second power output terminals **16***a* and **16***b*, namely the first power output terminal **16***a* is seen.

The second side wall of the case **27** is also formed with a through hole (not shown) into which a connecting cable **40** electrically connected to the cooling device **12** is inserted.

In the luminaire of the embodiment, the cooling device **12** of the electronic ballast **10** is fixed to an opposite side of the top base of the case **31** from the opening of the case **31**. In short, the cooling device **12** is fixed to the light source **20**. The cooling device **12** shown in the example of FIG. **4** includes a case **120** housing the rotor (the impeller) **13** and the driver **14** (see FIG. **1**), and slits **120***a* are formed in a peripheral wall of the case **120**.

Therefore, the luminaire of the embodiment can cool the light source **20** through the cooling device **12** and effectively dissipate heat transmitted from the solid-state light-emitting devices **21** to the case **31**.

In the luminaire of the embodiment, the light source **20** and the electronic ballast **10** are arranged individually (lighting system with separate ballast), but the invention is not limited to this. As an embodiment of the invention, the light source **20** and the electronic ballast **10** may be housed in the fixture body **24** so as to constitute a single luminaire (luminaire with built-in ballast).

As described above, the luminaire of the embodiment includes the light source **20** and the electronic ballast **10** configured to operate the light source **20**. Therefore, the luminaire of the embodiment can supply a stable voltage (the second operating voltage V**12**) to the cooling device **12**, and further prevent light source's (**20**) temperature from rising.

An electronic ballast **10** in accordance with an embodiment of the present invention is explained with reference to FIG. **5**. The electronic ballast **10** of the embodiment differs from the embodiment as shown in FIGS. **1** to **3** in that a first power supply **7** is configured to supply a first operating voltage V**11** to one of a first control circuit **5** and a second control circuit **6**, while a second power supply **8** is configured to supply a second operating voltage V**12** to a cooling device **12** and an other of the first control circuit **5** and the second control circuit **6**. In an example of FIG. **5**, the first power supply **7** is configured to supply the first operating voltage V**11** to the second control circuit **6**, while the second power supply **8** is configured to supply the second operating voltage V**12** to the cooling device **12** and the first control circuit **5**. Like kind elements are assigned the same reference numerals as depicted in the embodiment as shown in FIGS. **1** to **3** and not described in detail herein.

In the example of FIG. **5**, the first control circuit **5** is electrically connected to a positive side of a capacitor C**2** in the second power supply **8**.

In the electronic ballast **10** of the embodiment, a voltage across the capacitor C**2** is supplied as the second operating voltage V**12** to the first control circuit **5**. In this embodiment, it is unnecessary that the first power supply **7** supply the first operating voltage V**11** to the first control circuit **5**, and the first power supply **7** can be accordingly simplified in comparison with the first power supply **7** shown in FIGS. **1** to **3**.

In the example of FIG. **5**, a voltage across the capacitor C**2** in the second power supply **8** is supplied to the first control circuit **5**, but may be supplied to the second control circuit **6**. That is, as an alternative example, the second power supply **8** (an inductor L**2**) is configured to supply the second operating voltage V**12** to the second control circuit **6** in place of the first power supply **7**, while the first power supply **7** is configured to supply the first operating voltage V**11** to the first control circuit **5**.

As described above, in the electronic ballast **10** shown in FIG. **5**, the first power supply **7** is configured to supply the first operating voltage V**11** to the second control circuit **6**, while the second power supply **8** is configured to supply the second operating voltage V**12** to the cooling device **12** and the first control circuit **5**. As a result, in the electronic ballast **10**, the first power supply **7** can be simplified in comparison with the first power supply **7** in the embodiment as shown in FIGS. **1** to **3**.

The electronic ballast **10** of the embodiment may be applied to the luminaire shown in FIG. **4**.

An electronic ballast **10** in accordance with an embodiment of the present invention is explained with reference to FIG. **6**. The electronic ballast **10** of the embodiment differs from the embodiment as shown in FIGS. **1** to **3** in that a first power supply **7** is configured to generate a first operating voltage V**11** from a first DC voltage V**1** to supply the first operating voltage V**11** to a first control circuit **5** and a second control circuit **6**, while a second power supply **8** is configured to generate a second operating voltage V**12** from the first DC voltage V**1** to supply the second operating voltage V**12** to a cooling device **12**. Like kind elements are assigned the same reference numerals as depicted in the embodiment as shown in FIGS. **1** to **3** and not described in detail herein.

In an example of FIG. **6**, the second power supply **8** is configured to generate the second operating voltage V**12** for the cooling device **12**. In the embodiment, the first operating voltage V**11** is set to, for example, 12V and the second operating voltage V**12** is set to, for example, a voltage in a range of 5 to 12V.

In the example of FIG. **6**, the electronic ballast **10** includes a main controller **11** configured to individually control the first control circuit **5**, the second control circuit **6** and the second power supply **8**.

The second power supply **8** may be formed of, for example, a control IC or the like. In the embodiment, the second power supply **8** is formed of, but not limited to, MIP3530MS IPD for switching power supply, manufactured by Panasonic, like the first power supply **7** shown in FIG. **3**. In the example of FIG. **6**, a first output terminal **35***a* (see FIG. **3**) of the second power supply **8** is connected to a positive side of a capacitor C**1** in an AC-DC converter **3**, and a second input terminal **35***b* (see FIG. **3**) of the second power supply **8** is connected to a negative side of the capacitor C**1**. In addition, a first output terminal **36***a* (see FIG. **3**) of the second power supply **8** is connected to a driver **14**, and a second output terminal **36***b* (see FIG. **3**) of the second power supply **8** is connected to ground (not shown) of the electronic ballast **10**.

That is, the second power supply **8** is configured to generate the second operating voltage V**12** from a voltage across the capacitor C**1** in the AC-DC converter **3** (an output voltage of the AC-DC converter **3**) to supply the second operating voltage V**12** to the driver **14**.

Thus, in the electronic ballast **10** of the embodiment, the second power supply **8** configured to generate the second operating voltage V**12** for driving only the cooling device **12** is provided separately from the first power supply **7**, and it is accordingly possible to supply a stable voltage to the cooling device **12**. The second operating voltage V**12** is supplied from the second power supply **8** to the cooling device **12**, and therefore the electronic ballast **10** can further increase the second operating voltage V**12** for driving the cooling device **12** in comparison with the LED lighting device of Document 1 and employ the cooling device **12** having higher cooling capability. As a result, the electronic ballast **10** can further prevent light source's (**20**) temperature from rising in comparison with the LED lighting device of Document 1.

In the example of FIG. **6**, the main controller **11** is connected to the second power supply **8**. Accordingly, the main controller **11** can supply the second operating voltage V**12** to the driver **14** through the second power supply **8**, and activate the cooling device **12**.

As described above, the electronic ballast **10** of the embodiment includes the first power supply **7** configured to generate the first operating voltage V**11** for activating the first and second control circuits **5** and **6**, and the second power supply **8** configured to generate the second operating voltage V**12** for activating the cooling device **12**. In this electronic ballast **10**, the first power supply **7** is to generate the first operating voltage V**11** from the first DC voltage V**1** as the output voltage of the AC-DC converter **3**, and the second power supply **8** is to generate the second operating voltage V**12** from the first DC voltage V**1**. As a result, the electronic ballast **10** of the embodiment can supply a stable voltage (the second operating voltage V**12**) to the cooling device **12** and further prevent light source's (**20**) temperature from rising.

While the foregoing has described what are considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that they may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the present teachings.

The invention claimed is:

1. An electronic ballast, comprising:

an AC-DC converter comprising a chopper circuit configured to convert an AC voltage from a commercial power supply into a first DC voltage;

a DC-DC converter comprising a DC-DC conversion circuit configured to convert the first DC voltage into a second DC voltage to supply the second DC voltage to a light source including at least a solid-state light-emitting device;

a cooling device configured to cool the light source; and

a power supply comprising a first power supply configured to generate a first operating voltage from a first voltage obtained from the chopper circuit to supply the first operating voltage to at least one of the AC-DC converter and the DC-DC converter, and a second power supply configured to generate a second operating voltage from a second voltage obtained from the chopper circuit to supply the second operating voltage to at least the cooling device of the AC-DC converter, the DC-DC converter and the cooling device, wherein:

the chopper circuit comprises an inductor;

the AC-DC converter further comprises a first control circuit configured to control the chopper circuit;

the DC-DC converter further comprises a second control circuit configured to control the DC-DC conversion circuit;

the first power supply is configured to supply the first operating voltage to the first control circuit and the second control circuit, and the first voltage is the first DC voltage; and

the second power supply comprises an inductor magnetically coupled to the inductor of the chopper circuit and is configured to supply the second operating voltage to the cooling device, and the second voltage is obtained from the inductor of the second power supply.

2. An electronic ballast, comprising:

an AC-DC converter comprising a chopper circuit configured to convert an AC voltage from a commercial power supply into a first DC voltage;

a DC-DC converter comprising a DC-DC conversion circuit configured to convert the first DC voltage into a second DC voltage to supply the second DC voltage to a light source including at least a solid-state light-emitting device;

a cooling device configured to cool the light source; and

a power supply comprising a first power supply configured to generate a first operating voltage from a first voltage obtained from the chopper circuit to supply the first operating voltage to at least one of the AC-DC converter and the DC-DC converter, and a second power supply configured to generate a second operating voltage from a second voltage obtained from the chopper circuit to supply the second operating voltage to at least the cooling device of the AC-DC converter, the DC-DC converter and the cooling device, wherein:

the chopper circuit comprises an inductor;

the AC-DC converter further comprises a first control circuit configured to control the chopper circuit;

the DC-DC converter further comprises a second control circuit configured to control the DC-DC conversion circuit;

the first power supply is configured to supply the first operating voltage to one of the first control circuit and the second control circuit, while the second power supply is configured to supply the second operating voltage to the cooling device and an other of the first control circuit and the second control circuit; and

the second power supply comprises an inductor magnetically coupled to the inductor of the chopper circuit, and the second voltage is obtained from the inductor of the second power supply.

3. An electronic ballast, comprising:

an AC-DC converter comprising a chopper circuit configured to convert an AC voltage from a commercial power supply into a first DC voltage;

a DC-DC converter comprising a DC-DC conversion circuit configured to convert the first DC voltage into a second DC voltage to supply the second DC voltage to a light source including at least a solid-state light-emitting device;

a cooling device configured to cool the light source; and

a power supply comprising a first power supply configured to generate a first operating voltage from a first voltage obtained from the chopper circuit to supply the first operating voltage to at least one of the AC-DC converter and the DC-DC converter, and a second power supply configured to generate a second operating voltage from a second voltage obtained from the chopper circuit to supply the second operating voltage to at least the cooling device of the AC-DC converter, the DC-DC converter and the cooling device, wherein:

the AC-DC converter further comprises a first control circuit configured to control the chopper circuit;

the DC-DC converter further comprises a second control circuit configured to control the DC-DC conversion circuit;

the first power supply is configured to supply the first operating voltage to the first control circuit and the second control circuit, and the first voltage is the first DC voltage; and

the second power supply is configured to supply the second operating voltage to the cooling device, and the second voltage is the first DC voltage.

4. A luminaire, comprising:

a light source including at least a solid-state light-emitting device; and

an electronic ballast, comprising:

an AC-DC converter comprising a chopper circuit configured to convert an AC voltage from a commercial power supply into a first DC voltage;

a DC-DC converter comprising a DC-DC conversion circuit configured to convert the first DC voltage into a second DC voltage to supply the second DC voltage to the light source;

a cooling device configured to cool the light source; and

a power supply comprising a first power supply configured to generate a first operating voltage from a first voltage obtained from the chopper circuit to supply the first operating voltage to at least one of the AC-DC converter and the DC-DC converter, and a second power supply configured to generate a second operating voltage from a second voltage obtained from the chopper circuit to supply the second operating voltage to at least the cooling device of the AC-DC converter, the DC-DC converter and the cooling device,

wherein:

the AC-DC converter further comprises a first control circuit configured to control the chopper circuit;

the DC-DC converter further comprises a second control circuit configured to control the DC-DC conversion circuit;

the first power supply is configured to supply the first operating voltage to the first control circuit and the second control circuit, and the first voltage is the first DC voltage; and

the second power supply is configured to supply the second operating voltage to the cooling device, and the second voltage is the first DC voltage.

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